1. In a multiple-input/multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM) system, a method of synchronization a receiver to a signal, which includes at least one preamble, said method comprising:

receiving said signal at a receiver;

determining a first starting position by applying a sliding correlator algorithm to said received signal; and

subsequent to finding said first starting position, finding a second starting position by matching at least one stored preamble to said received signal.

2. The method according to Claim 1 wherein said sliding correlator is defined by the following relations:

$$\Lambda^i(x) = \left|\sum_{l=0}^{N_{symbol}-1} r^i{}_t(x+l)\, r^{i*}{}_t(x+N_{symbol}+l)\right| - \rho/2 \sum_{l=0}^{N_{symbol}-1} [|\, r^i{}_t(x+l)\,|^2 + |\, r^i{}_t(x+N_{symbol}+l\,|^2]$$

where

$\rho = \frac{SNR+1}{SNR}$;

$x_{coarse}{}^i = \arg\max(\Lambda^i(x)) \mid (\arg\max(\Lambda^i\ (x)) > le)$;

r^i_t is the received signals (from ith receiver antenna);

r^*_t is the conjugate of the received signal;

SNR is signal-to-noise ratio;

N_{sample} is the number of plurality of samples in one OFDM symbol; and,

le is a threshold value.

3. The method according to Claim 1 wherein said matching is performed using algorithms defined by the relations:

$$\Lambda_{o,j}(x) = \left| \sum_{l=0}^{\frac{N_{fft}}{2}} [r^{i}_{t}(x+l) + r_{t}(x + \tfrac{N_{fft}}{2} + l) + r_{t}(x + N_{symbol} + l) + r_{t}(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)] \right| pn_{o}^{*}(l)$$

and

$$\Lambda_{e,j}(x) = \left| \sum_{l=0}^{\frac{N_{fft}}{2}} [r_{t}(x+l) - r_{t}(x + \tfrac{N_{fft}}{2} + l) + r_{t}(x + N_{symbol} + l) - r_{t}(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)] \right| pn_{e}^{*}(l)$$

where

j=1 represents a first receiving antenna and j=2 represents a second receiving antenna;

$$pn_o = IFFT(PN_o);$$
$$pn_e = IFFT(PN_e);$$

$$\Lambda_2 = \Lambda_{o,1}\Lambda_{o,2}\Lambda_{e,1}\Lambda_{e,2};$$

$$x_{fine} = \arg\max(\Lambda_2(x));$$
$$x \in [x_{coarse} - N_{fine}, x_{coarse} + N_{fine}];$$

PN_o is a known Prime Number (PN) code used to modulate odd-indexed pilots;

PN_e is a known Prime Number (PN) code used to module even-indexed pilots;

N_{fft} is FFT size; and,

N_{fine} is a number of samples to be searched backwards and forwards around the starting position obtained from a prior synchronization.

4. The method according to Claim 1 wherein said matching at least one stored preamble to said received signal includes matching a plurality of stored preambles to said received signal.

5. The method according to Claim 1 wherein said receiver includes a plurality of receivers;

each of said plurality of receivers respectively receives said signal from a respective transmitter; and,

each of said plurality of receivers determines a respective first starting position by applying said sliding correlator algorithm to said received signal.

6. The method according to Claim 5 wherein:

said MIMO OFDM system includes a plurality of MIMO channels;

each of said MIMO channels has a plurality of sub-carrier channels; and,

each of said sub-carrier channels has identical sub-carrier spacing,

the method further comprising:

calculating a frequency offset for a multiple of the sub-carrier spacing for each of the plurality of MIMO channels;

calculating a frequency offset for a fraction of the sub-carrier spacing for each of the plurality of MIMO channels;

calculating a total frequency offset for each of said MIMO channels by summing said frequency offset for a multiple of the sub-carrier spacing for each MIMO channel with said frequency offset for a fraction of the sub-carrier spacing for each MIMO channel; and,

determining an average frequency offset for said plurality of MIMO channels by averaging the total frequency offset of each MIMO channel.

7. The method according to Claim 6 wherein said calculating a frequency offset for a multiple of the sub-carrier spacing for each of the plurality of MIMO channels further comprises calculating a shift of a pilot sub-carrier index for each preamble in the received signal.

8. The method according to Claim 7 wherein said calculating the shift of the pilot sub-carrier index is determined by the relations:

$$\Lambda_{i,j}(k) = \sum_{l=0}^{N_{tone}} R_{train}(k+l)PN^{*}{}_{i}(k_{\min}+l), \text{ where}$$

$(i, j = 1,2)$;

$l \in [-N_{\max}, N_{\max}]$;

$Z = \arg\max(\Lambda_{i,j}(k)) - k_{\min}$,

R_{train} is a received training symbol in frequency the domain;

K_{min} is an index of the first useful sub-carrier;

PN_i are known PN codes used by the transmitters; and

N_{max} is a value obtained from the expected maximum frequency offset.

9. The method according to Claim 6 wherein said calculating the frequency offset of a fraction of the sub-carrier spacing further comprises correlating two identical training symbols.

10. The method according to Claim 6 further comprising calculating a sampling clock offset by correlating two identical training symbols.

11. The method according to Claim 6 wherein said determining the frequency offset of a fraction of the sub-carrier spacing for each of the plurality of MIMO channels includes calculating values of and a slope of a curve defined by the relation:

$$\Lambda\ (l) = angle(R_{train1}(l)R^{*}_{train2}(l));$$

where R_{train} represents training symbols.

12. The method according to Claim 10 wherein said calculating said sampling clock offset includes calculating a slope of a curve defined by the relation:

$$\Lambda\ (l) = angle(R_{train1}(l)R^{*}_{train2}(l)).$$

13. Apparatus for synchronization in a multiple-input/multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM) system, a receiver to a received signal, said apparatus comprising:

storage means for storing at least one preamble;

receiver means coupled to said storage means, for receiving, a plurality of data frames, wherein each of said data frames includes at least one preamble and at least one symbol, and wherein said symbol includes a plurality of samples;

first synchronization means for applying a sliding correlator algorithm to said plurality of data frames; and,

second synchronization means for correlating a preamble in a data frame to said at least one preamble stored in said storage means.

14. The apparatus according to Claim 13 wherein said sliding correlator is defined by the following relations :

$$\Lambda^i(x) = \left| \sum_{l=0}^{N_{symbol}-1} r^i{}_t(x+l) r^{i*}{}_t(x+N_{symbol}+l) \right| - \rho/2 \sum_{l=0}^{N_{symbol}-1} [| r^i{}_t(x+l)|^2 + | r^i{}_t(x+N_{symbol}+l|^2];$$

where

$\rho = \frac{SNR+1}{SNR}$;

$x_{coarse}{}^i = \arg\max(\Lambda^i(x)) \mid (\arg\max(\Lambda^i\ (x)) > le)$;

$r^i{}_t$ is the received signals (from ith receiver antenna);

$r^*{}_t$ is the conjugate of the received signal;

SNR is signal-to-noise ratio;

N_{sample} is the number of plurality of samples in one OFDM symbol; and

le is a threshold value.

15. The apparatus according to Claim 13 wherein said second synchronization means is configured to perform in accordance with the relations:

$$\Lambda_{o,i}(x) = \left|\sum_{l=0}^{\frac{N_{fft}}{2}} [r'_i(x+l) + r_i(x + \tfrac{N_{fft}}{2} + l) + r_i(x + N_{symbol} + l) + r_i(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)]\right| pn_o^*(l)$$

;and

$$\Lambda_{e,i}(x) = \left|\sum_{l=0}^{\frac{N_{fft}}{2}} [r_i(x+l) - r_i(x + \tfrac{N_{fft}}{2} + l) + r_i(x + N_{symbol} + l) - r_i(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)]\right| pn_e^*(l);$$

where

j=1 represents a first receiving antenna and j=2 represents a second receiving antenna;

$$pn_o = IFFT(PN_o);$$
$$pn_e = IFFT(PN_e)$$
$$\Lambda_2 = \Lambda_{o,1}\Lambda_{o,2}\Lambda_{e,1}\Lambda_{e,2};$$

$$x_{fine} = \arg\max(\Lambda_2(x));$$

$$x \in [x_{coarse} - N_{fine}, x_{coarse} + N_{fine}];$$

PN_o is a known Prime Number (PN) code used to modulate odd-indexed pilots;

PN_e is a known Prime Number (PN) code used to module even-indexed pilots;

N_{fine} is a number of samples to be searched backwards and forwards around the starting position obtained from a prior synchronization.

16. The apparatus according to Claim 13 wherein said preamble further includes at least one pilot sub-carrier having an index and at least one training symbol;

the system further including:

calculating means for calculating a frequency offset for a multiple of the sub-carrier spacing for each of the plurality of MIMO channels;

means for calculating a frequency offset for a fraction of the sub-carrier spacing for each of the plurality of MIMO channels;

summing means for calculating a total frequency offset for each of said MIMO channels by summing said frequency offset of a multiple of the sub-carrier spacing for each MIMO channel with the frequency offset of a fraction of the sub-carrier spacing for each MIMO channel; and

averaging means for determining the average frequency offset for said plurality of MIMO channels by averaging the total frequency offsets of each MIMO channel.

17. The apparatus according to Claim 16 wherein said calculating means further comprises means for calculating a shift of the pilot sub-carrier index for each of the preambles in the plurality of data frames.

18. The apparatus according to Claim 17 wherein said means for calculating the shift of the pilot sub-carrier index for each of the preambles in the plurality of data frames is configured to operate in accordance with the relations:

$$\Lambda_{i,j}(K) = \sum_{l=0}^{N_{tone}} R_{train}(k+l)PN^{*}{}_{i}(k_{m}+l), \text{ where}$$

(i, j =1,2);

$l \in [-N_{max}, N_{max}]$;

$Z = \arg\max(\Lambda_{i,j}(K)) - k_{min}$;

R_{train} is a received training symbol;

K_{min} is an index of the first useful sub-carrier;

PN_i are known PN codes used by the transmitters; and

N_{max} is a value obtained from the expected maximum frequency offset.

19. The apparatus according to Claim 17 wherein said means for calculating the frequency offset of a fraction of the sub-carrier spacing for each of the plurality of MIMO channels further comprises means for correlating two identical training symbols.

20. The apparatus according to Claim 16 further comprising means for calculating a sampling clock offset by correlating two identical training symbols.

21. The apparatus according to Claim 16 wherein said means for determining the frequency offset of a fraction of the sub-carrier spacing for each of the plurality of MIMO channels is configured to calculate values of and a slope of a curve defined by the relation:

$\Lambda\ (l) = angle(R_{train1}(l)R^*_{train2}(l))$, where

R_{train} represents training symbols.

22. The apparatus according to Claim 20 wherein said means for calculating said sampling clock offset is configured to calculate a slope of a curve defined by the relation:

$$\Lambda(l) = angle(R_{train1}(l) R^{*}_{train2}(l)).$$

23. Apparatus for synchronization, in a multiple-input/multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM) system, a receiver to a received signal, said apparatus comprising:

a memory configured to store at least one preamble;

a receiver configured to receive a plurality of data frames ; wherein each of said frames includes at least one preamble and at least one symbol, said symbol including a plurality of samples;

a sliding correlator coupled to said receiver configured to apply a first synchronization algorithm to said data frames; and

a correlating synchronizer for applying a second synchronization algorithm to said data frames by correlating a preamble in a single data frame to a preamble stored in said memory.

24. The apparatus of Claim 23 wherein said sliding correlator operates in accordance with the relations :

$$\Lambda^{i}(x) = \left| \sum_{l=0}^{N_{symbol}-1} r^{i}_{l}(x+l) r^{i*}_{l}(x+N_{symbol}+l) \right| - \rho/2 \sum_{l=0}^{N_{symbol}-1} [| r^{i}_{l}(x+l)|^{2} + | r^{i}_{l}(x+N_{symbol}+l|^{2}];$$

where

$$\hat{\rho} = \frac{SNR+1}{SNR};$$

$$x_{coarse}^{i} = \arg\max(\Lambda^{i}(x)) \mid (\arg\max(\Lambda^{i}(x)) > le);$$

r_t is the received signal;

r^{*}_{t} is the conjugate of the received signal;

SNR is signal-to-noise ratio;

N_{sample} is the number of plurality of samples in one OFDM symbol; and,

le is a threshold value.

25. The apparatus of Claim 21 wherein said correlating synchronizer is defined by the relations:

$$\Lambda_{o,i}(x) = \left|\sum_{l=0}^{\frac{N_{fft}}{2}} [r^{i}_{t}(x+l) + r_{t}(x + \tfrac{N_{fft}}{2} + l) + r_{t}(x + N_{symbol} + l) + r_{t}(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)]\right| pn_{o}^{*}(l)$$

;

and

$$\Lambda_{e,i}(x) = \left|\sum_{l=0}^{\frac{N_{fft}}{2}} [r_{t}(x+l) - r_{t}(x + \tfrac{N_{fft}}{2} + l) + r_{t}(x + N_{symbol} + l) - r_{t}(x + N_{symbol} + \tfrac{N_{fft}}{2} + l)]\right| pn_{e}^{*}(l);$$

where

j=1 represents a first receiving antenna and j=2 represents a second receiving antenna;

$$pn_{o} = IFFT(PN_{o})$$
$$pn_{e} = IFFT(PN_{e});$$

$$\Lambda_{2} = \Lambda_{o,1}\Lambda_{o,2}\Lambda_{e,1}\Lambda_{e,2};$$

$$\hat{x}_{fine} = \arg\max(\Lambda_2(x));$$

$$x \in [x_{coarse} - N_{fine}, x_{coarse} + N_{fine}];$$

PN_o is a known Prime Number (PN) code used to modulate odd-indexed pilots;

PN_e is a known Prime Number (PN) code used to module even-indexed pilots; and,

N_{fine} is a number of samples to be searched backwards and forwards around the starting position obtained from a prior synchronization.

26. The apparatus according to Claim 23 wherein

said MIMO OFDM system includes a plurality of MIMO channels;

each of said MIMO channels has a plurality of sub-carrier channels; and,

each of said sub-carrier channels has identical sub-carrier spacing,

the apparatus further comprising:

a processor configured to calculate a frequency offset for a multiple of the sub-carrier spacing for each of the plurality of MIMO channels;

said process further configured to calculate a frequency offset for a fraction of the sub-carrier spacing for each of the plurality of MIMO channels;

said processor further configured to calculate a total frequency offset for each of said MIMO channels by summing said frequency offset for a multiple of the sub-carrier spacing for each MIMO channel with the frequency offset for a fraction of the sub-carrier spacing for each MIMO channel; and

said processor configured to determine an average frequency offset for said plurality of MIMO channels by averaging the total frequency offset of each MIMO channel.

27. The apparatus according to Claim 26 wherein said processor is configured to calculate a shift of the pilot sub-carrier index for each of the preambles in the plurality of data frames.

28. The apparatus according to Claim 26 wherein said processor is configured to apply said received signal to the relations:

$$\Lambda_{i,j}(k) = \sum_{l=0}^{N_{tone}} R_{train}(k+l)PN^{*}{}_{i}(k_{\min}+l), \text{ where}$$

(i, j =1,2);

$l \in [-N_{\max}, N_{\max}]$;

$Z = \arg\max(\Lambda_{i,j}(k)) - k_{\min}$;

R_{train} is a received training symbol;

K_{min} is an index of the first useful sub-carrier;

PN_i are known PN codes used by the transmitters; and

N_{max} is a value obtained from the expected maximum frequency offset.

29. The apparatus according to Claim 26 wherein said processor is configured to correlate two identical training symbols.

30. The apparatus of Claim 29 wherein said processor is configured to calculate a sampling clock offset by correlating said two identical training symbols.

31. The apparatus according to Claim 26 wherein said processor is configured to determine the frequency offset of a fraction of the sub-carrier spacing for each of the plurality of MIMO channels by calculating values of and a slope of a curve defined by the relation:

$\Lambda\ (l) = angle(R_{train1}(l)R^{*}_{train2}(l))$, where

R_{train} represents training symbols.

32. The apparatus according to Claim 30 wherein said processor is configured to calculate said sampling clock offset by calculating a slope of a curve defined by the relation:

$\Lambda\ (l) = angle(R_{train1}(l)R^{*}_{train2}(l))$

33. A method for synchronizing, in a multiple-input/multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM) system, a receiver to a received signal, said method comprising:

receiving a plurality of data signals at a plurality of receivers over a plurality of MIMO channels;

wherein each of said plurality of MIMO channels has a plurality of sub-carrier channels; and, each of said sub-carrier channels has identical sub-carrier spacing,

wherein said plurality of data signals each include at least one preamble and at least one symbol, and wherein said at least one symbol includes a plurality of samples;

separating at one of said plurality of receivers one of said plurality of signals from said plurality of signals

separating at another of said plurality of receivers another of said plurality of signals from said plurality of signals

respectively determining at said one of and said another of said plurality of receivers a starting position by applying a sliding correlator to the separated signals;

subsequent to determining said respective starting positions, respectively determining at said one of and said another of said plurality of receivers another starting position by traversing said separated signals from said respective starting positions and comparing at least one stored preamble to said separated signals until said at least one stored preamble matches said separated signal in at least one of. said one of and said another of said plurality of receivers.

34. The method according to Claim 33 further comprising:

subsequent to matching said at least one stored preamble to said separated signal:

determining a frequency offset for a multiple of the sub-carrier spacing for each of the plurality of MIMO channels;

determining a frequency offset for a fraction of the sub-carrier spacing for each of the plurality of MIMO channels;

determining a total frequency offset for each of said MIMO channels by summing said frequency offset for a multiple of the sub-carrier spacing for each MIMO channel with said frequency offset for a fraction of the sub-carrier spacing for each MIMO channel; and,

determining an average frequency offset for said plurality of MIMO channels by averaging the total frequency offset of each MIMO channel.

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